

USING SIMULATION TECHNOLOGY AS A NOVEL PREVENTION TOOL TO
COMBAT HEALTH CARE-ASSOCIATED INFECTIONS

A Dissertation

by

DELBERT BENNY HOLLAND

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Chair of Committee,	Murray J. Côté
Committee Members,	Tiffany A. Radcliff
	Darcy McMaughan
	Jerry Livingston
Head of Department,	Michael Morrisey

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ABSTRACT

Contact-related health care-associated infections (HAI) pose a significant threat to the morbidity and mortality of nursing home residents. The improper use of personal protective equipment (PPE) by nursing home staff has been identified as a factor in spreading contact-related HAIs to nursing home residents. The improper use of PPE contributes to undesirable resident health outcomes and poor resident safety practices associated with contact-related HAIs. The ability to measure PPE competency levels of nursing home staff is relatively unaddressed in the literature.

This research surmises that the ability to measure PPE competency levels of nursing home staff may lead to interventions that could reduce the risk of contact-related HAIs during physical contact between nursing home staff and residents. This study looks at one type of nursing home staff, the certified nursing assistant (CNA), and their competency levels in the use of PPE.

This research utilizes a novel methodology of clinical simulation technology combined with a PPE Rating Tool, SimPPERT (Simulation + PPE Rating Tool). This two-phase study evaluated the validity, reliability, and feasibility of using SimPPERT to measure PPE competency levels in a clinical simulation laboratory and in nursing homes. Phase I the validity and reliability of SimPPERT in a clinical simulation laboratory controlled experiment. Phase II examined the feasibility of utilizing SimPPERT with CNAs in the nursing home setting.

The ability to measure CNA PPE competency levels in nursing homes may provide a mechanism to identify deficiencies in PPE competency levels, analyze and identify the extent of those deficiencies, and provide insight and recommendations to improve resident health outcomes and safety related to contact-related HAIs in nursing homes.

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NOMENCLATURE

AHRQ	Agency for Healthcare Research and Quality
CDC	Center for Disease Control and Prevention
CDI	<i>Clostridium difficile</i> infections
CMS	Centers for Medicare and Medicaid Services
CNA	certified nursing assistant
DVD	digital video disc
GI	gastrointestinal
HAI	health care-associated infections
ICC	intraclass correlation coefficient
IRR	interrater reliability
PPE	personal protective equipment
RN	registered nurse
SimPPERT	simulation + PPE rating tool
SME	subject matter expert
TAPS	tools for assessment of PPE skills
TEP	technical expert panel
TMF	Texas Medical Foundation

1. INTRODUCTION AND LITERATURE REVIEW

Health care-associated infections (HAI) of all types and in all health care settings have been targeted for elimination by the health care community (Cardo et al., 2010). These efforts have produced significant reductions in some types of HAIs, but *Clostridium difficile* infections (CDI), one type of HAI, have proven to be resistant to these efforts from the mid-1990s to 2014 (Lucado, Gould, & Elixhauser, 2012; McDonald et al., 2012). CDI is a transmission-based HAI through physical contact between health care personnel and patients (McDonald et al., 2012) that has, so far, been resistant to elimination efforts.

This two-phase study focuses on the quality of personal protective equipment (PPE) usage by certified nursing assistants (CNA) and their role in contributing to transmission-based HAIs, such as CDI, in nursing homes. Cardo et al. (2010) acknowledged that the effort to eliminate HAIs would require implementation of evidence based practices, the closing of knowledge gaps, and development of novel prevention tools. This study addresses the issue by using evidence-based metrics to measure PPE competency levels of nursing home CNAs, addressing a gap in the knowledge related to measurement of CNA PPE competency levels, and evaluating a novel prevention tool that combines clinical simulation technology with a PPE Rating Tool, SimPPERT (Simulation + PPE Rating Tool).

This study demonstrates SimPPERT is a reliable and valid methodology for measuring CNA PPE competency levels and SimPPERT is a feasible methodology

capable of implementation in the nursing home setting. The study also discusses the potential for SimPPERT to reduce the risk of transmission-based HAIs in nursing homes by ensuring the maintenance of evidence based practices for nursing home CNA PPE usage. I evaluated the reliability and validity of the SimPPERT methodology in Phase I.

The PPERT is an instrument developed by Williams and Carnahan (2013) to measure PPE knowledge and skill levels of health care professionals and students and used with their permission in this study. Williams and Carnahan (2013) utilized a Delphi methodology to develop a set of Tools for Assessment of PPE Skills (TAPS). TAPs consisted of three checklists for hand hygiene and donning/doffing of PPE and a global rating scale. The checklists were scored on a dichotomous pass/fail scale of awarding 1 point for each task done correctly and 0 points for each task done incorrectly, or not done. The global rating scale consisted of six global rating items scored on a Likert scale from 0 (not applicable) to 5 (done perfectly). The Williams and Carnahan (2013) study developed the TAPS measurement tools and tested TAPS reliability (i.e., consistency in measuring the same items) and construct validity (i.e., ability to measure the intended construct). The global rating scale was adapted from Williams and Carnahan (2013) study and used in this study as the PPERT measurement tool.

Williams and Carnahan (2013) utilized both aspects of TAPS, the checklists and global rating scale, to measure the PPE skills competency levels of novice and experienced health professionals. Their intent was to determine if TAPS could distinguish between a novice and experienced PPE skills competency level. Some of the Williams and Carnahan (2013) methodology was similar to this study's methodology,

e.g., video recording of PPE skills demonstrations in a laboratory setting. However, the intent of the testing for this study was to measure the PPE skills competency levels of CNAs in the nursing home setting, not to distinguish between novice and experienced health professionals. This study does not utilize the checklist aspects of the TAPS utilized in the Williams and Carnahan (2013), but only the global rating scale, which is called the PPERT in this study. The researcher performed reliability and validity testing of the PPERT as a stand-alone measurement tool of CNA PPE skills competency levels in a clinical simulation scenario of a nursing home setting.

The Agency for Healthcare Research and Quality (AHRQ) funded the majority of this research in a study titled “Preventing and/or managing *Clostridium difficile* among nursing home residents, admissions and discharges.” The AHRQ study, award number 5R18HS01998902, [started 9/30/2011 and ended 7/31/2013](#). The AHRQ study approached the problem of managing or preventing *Clostridium difficile* through multiple approaches. This dissertation addresses Aim #1 of the AHRQ study, “Improving nursing home management of *Clostridium difficile* using a state-of-the-art infection control bundle.” Aim #1 of the AHRQ study occurred during 2012 and 2013.

1.1 Health-care Associated Infections

Horan, Andrus, and Dudeck (2008) define HAI in the acute care setting as:

“...a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s). There must be no evidence that

the infection was present or incubating at the time of admission to the acute care setting. HAIs may be caused by infectious agents from endogenous or exogenous sources.

- Endogenous sources are body sites, such as the skin, nose, mouth, gastrointestinal (GI) tract, or vagina that are normally inhabited by microorganisms.
- Exogenous sources are those external to the patient, such as patient care personnel, visitors, patient care equipment, medical devices, or the health care environment” (p. 1).

HAIs come from many different organisms, many different vectors of transmissions, and in many different health care settings (Horan, Andrus, & Dudeck, 2008). HAIs have been estimated to increase direct and indirect costs in U.S. acute-care hospitals approximately \$96 to \$147 billion annually adjusted to 2010 dollars (Marchetti & Rossiter, 2013), or \$104 to \$159 billion annually adjusted to 2016 dollars.

HAIs pose a significant threat to the morbidity and mortality of patients across the spectrum from newborn to elderly, in both hospitals and nursing homes (Klevens et al., 2007; Salazar, Baskin, Garey, & DuPont, 2009; Simor, 2010; Smith et al., 2008; Strausbaugh & Joseph, 2000). A 2010 multistate survey conducted to estimate the prevalence of HAIs in the U.S. found *Clostridium difficile* to be the most commonly reported HAI pathogen and recommended developing effective prevention measures for transmission-based HAIs such as CDI (Magill et al., 2014). A landmark policy change in

2008 by the Centers for Medicare and Medicaid Services (CMS) specifically targeted HAIs by ceasing payment for certain health-care associated infections not present on admission and considered “reasonably preventable” as an incentive for health care providers to be more vigilant in preventing HAIs (Milstein 2009). These efforts to reduce HAIs have produced various levels of success in decreasing HAI in the health care setting.

CDI causes diarrhea and can lead to toxic megacolon and death especially in older populations such as nursing home residents (Campbell et al., 2009). Between 2000 and 2009, the incidence of most HAIs appeared to be declining, but the incidence of CDI, a transmission-based HAI, increased during the same time period (Lucado et al., 2012; McDonald et al., 2012). The Center for Disease Control and Prevention (CDC) 2014 National and State Healthcare-Associated Infections Progress Report provides the latest information on national progress toward eliminating HAIs among acute care hospitals, long-term acute care hospitals, and inpatient rehabilitation facilities (CDC, 2016). The CDC reports various rates of continued success between 2008 and 2014 in decreasing some HAIs such as central line associated bloodstream infections (i.e., 50% decrease) and surgical site infections (i.e., 17% decrease), but only an 8% decrease between 2011 and 2014 for CDI, and no change in the rate of catheter associated urinary tract infections (CDC, 2016). These results indicate CDI remains resistant to current HAI elimination efforts.

In 2007, for the 65 years and older age group, CDI ranked among the top 20 causes of U.S. deaths and accounted for approximately 92% of all CDI-related U.S.

deaths. (Gruneir et al., 2010). One study estimated in 2011 there were 29,000 United States deaths associated with CDI and 15,000 United States deaths directly attributable to CDI (Lessa et al., 2015). Lessa et al. (2015) estimated approximately 12,000 of the 15,000 deaths directly attributable to CDI in 2011 were in the 65 years and older age group (Lessa et al., 2015). The 65 years and older age group is highly representative of nursing home residents (Mody, 2007). Improper use of PPE in the performance of contact precaution procedures by CNAs is considered a potential contributor to the presence of transmission-based HAIs in nursing homes and, thereby, directly related to poor patient outcomes for nursing home residents (Mody, 2007; Mody, Langa, Saint, & Bradley, 2005; Roup, Roche, & Pass, 2006).

During October, 2014, two health care workers in Texas became infected with Ebola virus while they were providing health care for a patient infected with Ebola virus (Thompson, 2014b). While both health care workers eventually recovered from the disease (Thompson, 2014a), CDC director Dr. Tom Frieden stated that PPE protocols were breached during the provision of patient care resulting in the health care workers becoming infected with the Ebola virus (CDC 2014c). This incident offers additional insight into how failure to follow evidence based practices for the use of PPE can lead to serious health outcomes.

Mody (2007) identified the improper use of PPE as a problem with nursing home infection control programs and a contributor to undesirable resident health outcomes and poor resident safety practices associated with transmission-based HAIs. Another study suggested PPE competency levels of nursing home CNAs are a significant contributor to

the issue of transmission-based HAIs and nursing home resident health outcomes and safety (Matheï, Niclaes, Jans, & Buntinx, 2007). The lack of an effective method to measure the PPE competency levels of CNAs delivering health care services to nursing home residents appears to be a complication to ensuring proper usage of PPE by CNAs. Providing an effective method of measuring PPE skills competency may assist in identifying those nursing homes and CNAs in need of remediation training to meet a minimal level of PPE skills competency. Nursing homes and regulatory agencies can use this knowledge to implement training programs to address the PPE competency level deficiencies, which should decrease the incidence of transmission-based HAIs and result in improved resident health outcomes and resident safety. Figure 1 provides a conceptual illustration of how low competency levels of PPE usage in nursing homes can increase the risk of HAI to residents, and how high competency levels of PPE usage in nursing homes can decrease the risk of HAI to residents.

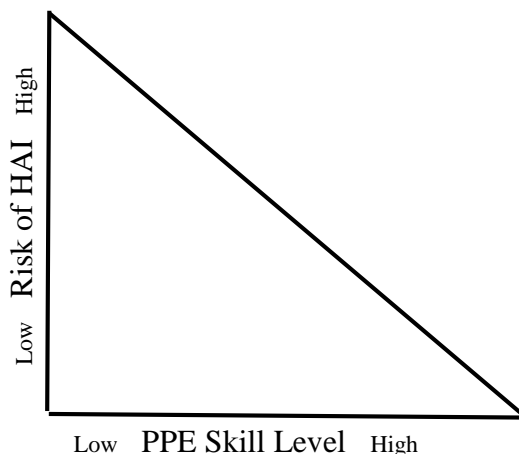


Figure 1: Conceptual Relationship between PPE Competency Levels and Risk of HAI

This study focuses on nursing home resident care personnel (i.e., certified nursing assistants), resident care equipment (PPE), and transmission-based HAIs acquired through physical contact between nursing home certified nursing assistants (CNA) and nursing home residents during the delivery of health care services. Many studies have examined the reduction of transmission-based HAIs associated with PPE usage by health care personnel from a compliance perspective (Beam, Gibbs, Boulter, Beckerdite, & Smith, 2011; Cromer et al., 2004; Manian & Ponzillo, 2007; Ross et al., 2011; Weber et al., 2007). However, there is a paucity of studies in the literature that look at the issue from the perspective of PPE competency levels (McKinley et al., 2008). This study addresses a gap in the literature on PPE competency level measurement by providing knowledge and information on measurement of PPE competency levels through evaluation of the SimPPERT method of measuring PPE competency levels of CNAs in nursing homes.

1.2 PPE Implementation in Nursing Homes

Mody (2007) identified an increased risk of HAIs due to factors which included difficulties in establishing and maintaining effective infection control measures, along with inconsistent training and supervision of nursing home staff within the nursing home setting. Unlike the acute care setting where health care is delivered on a short term basis, nursing home residents are more susceptible to acquiring transmission-based HAIs due to unique characteristics of the nursing home setting (Mody, 2007; Smith et al., 2008).

These characteristics include increased prevalence of chronic diseases, high staff turnover leading to challenges in assuring all staff are educated and trained in infection control practices, and the institutional environment involving frequent physical contact with nursing home CNAs and other residents (Mody, 2007; Smith et al., 2008).

The threat to nursing home residents' health outcomes and safety is complicated by difficulties in training and supervising nursing home CNAs in infection control practices such as competent performance of PPE skills when caring for residents on contact precautions (Mody, 2007). The CDC (2012) states a facility with a well-planned and implemented infection control program can reduce HAI by 70%. Many health care settings, including nursing homes, recognize infection control programs as the best defense against HAI (Matheï et al., 2007; Pratt et al., 2005; Raka, 2009; Sacar et al., 2006; Siegel, Rhinehart, Jackson, & Chiarello, 2007). However, few studies have examined the efficacy of the overall infection control program, or specific components of the program (Matheï et al., 2007). Mody, Langa, Saint, & Bradley (2005) conducted a survey of 105 nursing homes in Michigan and discovered that inadequate infection control programs and poorly defined guidelines for those programs potentially contributed to higher infection rates of diseases, including HAIs. Mathei (2007) explains that while established guidelines of best practice for infection control and epidemiology for the acute hospital exist, cannot be implemented in nursing homes due to differences between the acute hospital and nursing home settings, including the lack of dedicated infection control practitioners and the potential for lower staff education levels. The lack of studies evaluating the efficacy of specific infection control practices in nursing homes

and the lack of infection control guidelines specifically designed for nursing homes are areas of concern for the prospective health outcomes and safety of nursing home residents (Matheï et al., 2007; Mody et al., 2005). This study focuses on one portion of the infection control program, adherence to PPE usage guidelines, which can be determinable by measurement of PPE competency levels of CNAs in the nursing home. The knowledge of the PPE competency levels of CNAs in a nursing home should provide an indication of the effectiveness of the nursing home infection control program.

The threat to resident safety and the undesirable health outcomes of acquiring a HAI are profound for nursing home residents and can include social isolation, functional decline, and death (Smith et al., 2008). HAIs are considered preventable and steps to improve patient safety by decreasing HAI rates have been identified by healthcare organizations, professional associations, government and accrediting agencies, legislators, regulators, payers, and consumer advocacy groups (Yokoe et al., 2008). Initiatives to reduce the prevalence of HAIs in health care settings are ongoing and promising (CDC 2014b). These initiatives include education of physicians on carefully prescribing antibiotics to vulnerable populations, education of health care professionals on the placement and care of indwelling catheters (e.g., central venous access lines and urinary catheters), along with increased vigilance for infection control in the operating room have yielded remarkable results (CDC 2014a). Between 2000 and 2009, the incidence of most HAIs appeared to be declining, but the incidence of some transmission-based HAI increased during the same time span (McDonald et al., 2012). The National Vital Statistics Report for 2010 reveals more than 91% of deaths due to

CDI occurred in those 65 and over and CDI was ranked as the 18th leading cause of death for that age group (Murphy, Xu, & Kochanek, 2013). A study of CDIs in the United States for 2011 estimated the number of deaths in the United States attributed to CDIs to be about 15,000 for that year (Lessa et al., 2015). The high incidence rates of CDIs in the elderly continue to be a threat for nursing home residents. The quality of contact precaution procedures by CNAs utilizing PPE is considered a potential factor in the spread of transmission-based HAIs in nursing homes and directly related to resident safety and resident health outcomes (Mody, 2007; Mody et al., 2005; Roup et al., 2006).

1.3 Measuring PPE Skills Competency

Mody (2007) explains that infection control education of CNAs is a valuable tool for combating HAIs in nursing homes, but acknowledges the difficulty in ensuring the education is performed adequately and consistently. Mody (2007) cites a lack of regulatory oversight of infection control programs and inherent nursing home characteristics, such as time and resource limitations, high staff turnover rates, and high patient-to-staff ratios as reasons for inadequately and inconsistently performed infection control program education. Competent use of PPE is an important part of an infection control program educational efforts (CDC 2012). Evaluating the effectiveness of nursing home CNA PPE education efforts by measurement of PPE competency levels may provide an indicator of the likelihood of preventing transmission-based HAIs in the nursing home setting and improving nursing home residents' health outcomes and

safety. The literature reveals little about how to measure PPE competency levels of nursing home CNAs. A method of measuring PPE competency levels may provide a means to predict the likelihood of competent performance of PPE skills when providing care to nursing home residents. SimPPERT may offer an effective method of improving both nursing home residents' health outcomes and patient safety through the ability to measure and assure a minimum level of nursing home CNA PPE competency. While this study does not evaluate the effectiveness of the SimPPERT methodology to improve nursing home residents' health outcomes and safety, the potential for SimPPERT reported PPE skills levels to be utilized to improve the health outcomes and safety of nursing home residents is examined in more detail in the discussion section, chapter 4.0.

1.4 Clinical Simulation

Simulation of real life in a controlled setting for the purpose of training individuals in a particular skill has its roots in ancient history. Roman soldiers practiced warfare with a quintain as early as the first century A.D. (Buck, 1990). Buck (1990) described the quintain as a vertical shaft with a cross member which had a target on one end and a counterweight on the other end which simulated an enemy soldier. The Roman army felt it was best to thrust with a sword rather than slash or chop. When the trainee struck the target incorrectly, the blow propelled the counterweight into the trainee, thereby providing feedback to the trainee that the action was incorrect. In more modern times, flight simulators have been utilized to simulate flying an airplane to safely train

aircrew by permitting practice of flight in difficult situations like wind shear or aircraft stalls (Rolfe & Staples, 1988). Medical education utilized simulation for training of student physicians as far back as 1849 when manikins were used to simulate childbirth in teaching obstetrics students (Owen, 2012).

Health professional education has successfully applied clinical simulation technology combined with focused skills rating rubrics to measure competency levels of students (Issenberg, 2008; Jeffries, 2005; Jeffries, McNelis, & Wheeler, 2008; Nehring & Lashley, 2004, 2009). Clinical simulation is accomplished by the use of clinical scenarios where manikins (or human actors) are the patients and the student performs skills and procedures as if in an actual clinical setting (Jeffries et al., 2008; Nehring & Lashley, 2004). Clinical simulation scenarios immerse a student in a simulated clinical environment to demonstrate the translation of didactic knowledge into clinical skills and provides the means for evaluating the student's competency level in performance of clinical skills (Jeffries, 2005; Jeffries et al., 2008; Ogden, Cobbs, Howell, Sibbitt, & DiPette, 2007).

Beyond health professional students' clinical skills training and assessment, medical educators have successfully utilized simulation technology in teaching clinical skills to resident physicians and physicians. Bruppacher, et al, (2010) demonstrated clinical simulation technology was significantly better than traditional, expert interactive seminar training in acquisition of education and skills to improve the ability of anesthesia residents and fellows in weaning patients from cardiopulmonary bypass, both in post-tests and retention tests results. Other studies have demonstrated the successful

use of clinical simulation technology to improve health professional skills competency in areas including but not limited to emergency response, critical care, and code blue teams (Jeffries et al., 2008; Scott et al., 2006; Villamaria et al., 2008). Even though direct observation of patient care provision appears to be used more than clinical simulation for measuring infection control compliance of practicing health professionals, clinical simulation may prove to be an effective method to measure PPE competency levels of CNAs in nursing homes (Bertrand, Babu, Polgreen, & Segre, 2010; McKinley et al., 2008; Ross et al., 2011; Weber et al., 2007).

1.5 Reliability and Validity Theoretical Underpinnings

Reliability and validity of the SimPPERT methodology was assessed with principles related to interrater reliability (IRR). IRR is an assessment of the internal consistency between the items being rated as well as the proportion of agreement between the two or more judges assessment results of the same set of items (Pantzare, 2015). Stemler (2004) describes three categories that may be used for computing interrater reliability: consensus estimates, consistency estimates, and measurement estimates. Consensus estimates provide the degree to which judges agree on the interpretation of the construct being studied. Consistency estimates provide an estimate of the judges consistency in providing the same assessment of each item based on their interpretation of the scale being utilized. Measurement estimates assume that all judges'

information, even the discrepancies between judges, are useful in providing a summary score of the proportion of agreement between the judges (Stemler, 2004).

This study applied all three approaches to the question of reliability and validity of the SimPPERT methodology to measure CNA PPE skills competency in both the laboratory and nursing home settings. Cronbach's alpha values were calculated to assist in evaluating the internal consistency between the items being rated in the use of the SimPPERT measurement form and the consensus between judges in a face validity study to assess the fidelity of videos demonstrating various levels of PPE skills performances. Intraclass correlation coefficient (ICC) values were calculated to provide a measurement of the proportion of agreement between the judges, or raters, in this study.

1.6 Research Questions

The research questions answered in this study focus on the reliability and validity of the SimPPERT methodology to measure CNA PPE skills levels. Reliability refers to a measurement instrument's capability to repeatedly reproduce the same measurements of an item. Validity refers to the measurement instrument's ability to accurately measure the construct of the item being measured. It is understood that that reliability and validity empirical testing does not qualify a measurement tool as reliable and valid based on the testing values, but rather provide evidence to support the likelihood of the measurement tool to be considered as reliable and valid (Cook & Beckman, 2006). As explained by Cook and Beckman (2006), both reliability and validity of an instrument can be measured in various ways. This study utilized Cronbach's alpha, a measure of internal

consistency of the items, and the intraclass correlation coefficient (ICC), a measure of the proportion of agreement between the raters, to provide values to support or refute the reliability and validity of the SimPPERT methodology to measure CNA PPE skills levels.

The literature review shows a gap in the knowledge related to measuring the PPE skills competency levels of CNAs in nursing homes and the paucity of studies examining methods for measuring PPE skills competency levels of CNAs in nursing homes. This study examined a novel approach to addressing that gap in knowledge by utilizing the SimPPERT methodology to measure the PPE skills competency levels of CNAs in nursing homes. The study provided answers to two research questions involving the reliability and validity of SimPPERT to measure CNA PPE skills levels as well as the feasibility of utilizing SimPPERT in nursing homes as a measurement tool and methodology in situ. The research questions this study answered are below.

Question #1: Is SimPPERT a reliable and valid method for the measurement of CNA PPE competency levels?

Question #2: Is SimPPERT a feasible method of measuring CNA PPE competency levels in nursing homes?

2. METHODS

This study was conducted in two phases. Phase I examined the reliability (i.e., consistency in measuring the same items) and face validity (i.e., ability to measure the intended construct) of the SimPPERT methodology to measure CNA PPE skills competency levels using laboratory-produced videos of a CNA actor portraying various levels of PPE skills competency. The researcher used two technical expert panels (TEP) to provide data for assessing the reliability and validity of the SimPPERT methodology. TEP #1 consisted of nine registered nurses (RNs) who volunteered their time and expertise to view SimPPERT produced videos of CNA PPE skills performances and rate those PPE performances utilizing the PPERT rating tool. TEP #2 was engaged for a face validity study and consisted of seven RNs and two CNAs who provided their time and expertise to view the SimPPERT produced videos. TEP #2 utilized a Likert scale developed to provide ratings of the construct validity of the videos in depicting various levels of PPE skills performances. The data gathered from the TEP ratings provided the results that were analyzed to test Research Question #1 namely, is SimPPERT a reliable and valid method for the measurement of CNA PPE competency levels?

The face validity study conducted in 2015 was not part of the original AHRQ study, but was conducted additionally. This study uses Aim #1 of the AHRQ study: improving nursing home management of *Clostridium difficile* using a state-of-the-art infection control bundle. Aim #1 was conducted in 2012-2013 and included the development and implementation of a novel methodology for measuring the PPE skills

competency levels of nursing home CNAs through clinical simulation technology and a PPE rating tool. This study refers to that novel methodology as SimPPERT.

Phase II of this study consisted of implementing the SimPPERT methodology in actual nursing homes with working CNAs to test the feasibility of utilizing SimPPERT in situ. One hundred and twenty CNAs were videoed demonstrating their PPE skills competency during a clinical simulation scenario of providing care to a nursing home resident with CDI. Two RN raters viewed each video and provided a skills competency score on a rating form. The results of Phase II provided the information to test Research Question #2: is SimPPERT a feasible method of measuring CNA PPE competency levels in nursing homes?

2.1 Phase I –Reliability & Validity Study

A quasi-experimental design for the reliability and validity testing of the SimPPERT methodology in Phase I of this study. Two convenience samples of raters provided their expert opinions of the quality of PPE skill performances provided on video recordings produced by the researcher. No control group or other components were utilized by the study to assess the reliability and validity of SimPPERT. Eight video recordings of a CNA actor providing care to a resident on contact precautions demonstrated various levels of PPE competency, including bad, average, and good. The videos were viewed by the TEP #1 and scored utilizing the PPERT measurement tool.

Each video was designed to represent a bad, average, or good performance of PPE skills competency. The various PPE skills level demonstrated in each video were produced by following various PPERT form explanations of ranking for each of the six dimensions of PPE skills. The PPERT explanations describe deficiencies in the evidenced based practice PPE guidelines provided by the CDC and intended to demonstrate various levels of quality in performing PPE skills ranging from bad, to average, to good. The video PPE skills performances were the independent variables in the quasi-experimental design. The TEP #1 PPERT scores derived from viewing the videos were the dependent variables in the quasi-experimental design.

A Likert scale survey was designed for the TEP #2 to ascertain if SimPPERT methodology was valid in accurately distinguishing between the bad, average, and good PPE competency demonstration videos. The validity of the SimPPERT methodology was dependent on the agreement of the TEP #2 with the designed ranking of the laboratory videos as bad, average, or good. A good level of agreement between the designed video rankings and the TEPs video rankings would suggest the SimPPERT methodology was valid in accurately measuring PPE competency levels.

The simulation technology components of the quasi-experimental design include the PPERT measurement tool, the clinical simulation scenario, the CNA actor, the manikin, a hospital bed, a simulated infectious agent, and video camcorders. The CNA actor demonstrated PPE utilization based on a clinical simulation scenario script to depict various levels of CNA PPE competency. The PPERT instrument used by both

TEPs provided a measurement of a health care professionals' knowledge and skills levels on proper PPE usage (Williams & Carnahan, 2013).

The PPERT rates six dimensions of PPE competency on a five-category scale. The rater assigns a Likert rating of 1 to 5 (i.e., 1 is worst and 5 is best) for each of the six dimensions while observing the demonstration of PPE competency. In this manner, the rater provides an assessment of the PPE competency level of the performer from six dimensions of proper PPE utilization, which permits identification of participant deficits by dimension. The six dimensions of the PPERT are:

1. Care and Risk Assessment – critical risk assessment, understanding of the situation; appropriate selection of PPE
2. PPE Handling – correct and careful use of PPE
3. Flow of Operation – forward planning and continuity of procedure
4. Self-Contamination – avoidable/unnecessary contamination of PPE user during or after care activities
5. Contamination of Environment – contamination of environmental surfaces during or after care activities
6. Cross Contamination – contamination of client/patient due to contaminated PPD used between care activities and procedures.

Each of the six dimensions are anchored by descriptive narration of the dimension's task at the Likert levels of 1, 3, and 5. The Likert ratings of 2 and 4 are designed to permit the

rater to select a score between the adjacent two rating descriptive narrations and represents a qualified, rather than exact, evaluation of the dimension.

The study evaluated the PPERT's reliability and validity in measuring CNA PPE competency during a clinical simulation scenario. Eight scenarios were designed depicting bad, average, and good performances of PPE skills competency levels. The clinical simulation scenarios were designed following the CDC (2012) guidelines for PPE utilization by health care professionals and in the CDC sanctioned article by the Healthcare Infection Control Practices Advisory Committee which details infection control guidelines in health care settings (Siegel et al., 2007). The researcher then intentionally violated or circumvented these guidelines to some degree in order to create the bad and average scenarios. These clinical scenarios of various levels of CNA PPE competency were video recorded for viewing and rating utilizing the PPERT.

A nursing student proficient in PPE utilization portrayed a nursing home CNA in the clinical simulation scenarios. The CNA actor utilized PPE to provide personal care for a bed-bound nursing home resident on contact precautions in the clinical simulation scenario. A manikin placed in a bed portrayed the nursing home resident for the clinical simulation scenarios. Camcorders captured digital video recordings of the CNA performance during the scenarios. The CNA performer verbalized rationales for each step of the procedure as she selected and donned PPE prior to entering the room, provided personal care by changing the soiled briefs of the resident (manikin), and then doffed the PPE equipment.

The researcher developed eight versions of the clinical simulation scenario to demonstrate varying levels of PPE skills competency ranging from very incompetent (i.e., bad) to highly competent (i.e., good). Video #1 and #7 depict a good CNA PPE competency level, which follows the CDC guidelines completely. Video #2 depicts a bad CNA PPE competency level with egregious failures to follow the CDC guidelines involving contamination of self, the environment, or the patient. Videos #3, #4, #5, #6, and #8 depict average CNA PPE competency levels with minor deviations from the CDC guidelines. See Table 1 for a listing of the laboratory-produced videos designed performance ratings.

Table 1: Video Designed Performance Ratings and PPERT Task Issues

Video #	PPERT Tasks with Issues	Designed Level
1	No Issues - Perfect	Good
2	Care and Risk Assessment; PPE Handling; Self-Contamination	Bad
3	Care and Risk Assessment; Flow of Operation; Minor Self-Contamination	Average
4	Care and Risk Assessment; PPE Handling	Average
5	Care and Risk Assessment	Average
6	Flow of Operation; Minor Self-Contamination	Average
7	No Issues – Perfect	Good
8	PPE Handling	Average

Nine RN raters with experience in utilizing, teaching, and training proper use of PPE served on the TEP #1. Two of the nine TEP #1 members experienced technical or

logistical issues, which resulted in their non-participation in the study. The remaining seven TEP #1 members viewed the clinical simulation scenario videos produced in the laboratory setting and provided a PPE competency level rating of the CNA performer using the PPERT.

The TEP #1 members were trained on proper utilization of the PPERT through a webinar presentation that included:

1. A Power Point presentation on the content of the PPERT form, how to complete the PERT form, instructions on how to access the videos for viewing, and how to return the completed PPERT forms to the study.
2. Copies of the CDC guidelines for donning and doffing PPE in both poster and Power Point slide formats.
3. A document containing detailed examples of scoring PPE performances with the PPERT.

The TEP #1 raters followed the CDC guidelines for PPE usage as the benchmark standard for obtaining a rating score of the demonstrated PPE competency performances in the videos. The TEP #1 raters had access to the recorded webinar on PPERT usage for future reference as needed. The TEP #1 raters viewed the videos and provided a rating score for each of the six dimensions.

The study desired to ascertain how accurately the videos produced to demonstrate various levels of PPE skills competency. A face validity study was designed to assess the perceptions of a panel of health care professionals familiar with PPE skills.

A second TEP (TEP #2) provided a panel of health care professionals who viewed the videos and provided a rating of their opinion of how well each video portrayed proper use of PPE. TEP #2 consisted of two CNAs and seven RNs with experience in utilizing PPE in a clinical setting. The TEP #2 participants received a \$20 gift card as an incentive to participate in the face validity portion of the study. All prospective TEP #2 candidates received informed consent information. The researcher provided the TEP participants with the scope of the study and gave them opportunity to ask questions for clarification. Each TEP #2 member received access to the eight laboratory-produced videos and a face validity survey form. The survey form used a 5-point Likert scale including very bad, bad, average, good, and very good.

Each member of the TEP #2 individually viewed the eight laboratory-produced videos showing a CNA actor demonstrating various levels of PPE usage ranging from very bad to very good. After viewing each video, the TEP #2 member provided a rating of their assessment of how well the video demonstrated proper usage of PPE by the CNA actor. Table 2 lists the designed levels of PPE performance in the laboratory-produced videos, the intended Likert scale rating and the expected TEP #2 performance ranking.

Table 2: Video Designed Performance, Likert Score and Expected Ranking

Video #	Designed PPE Performance	Designed Likert Score	Expected TEP #2 Ranking
1	Good	5	#1
2	Bad	1	#8
3	Average	3	#3 - #7
4	Average	3	#3 - #7
5	Average	3	#3 - #7
6	Average	3	#3 - #7
7	Good	5	#2
8	Average	3	#3 - #7

2.2 Phase II – Feasibility Study

Phase II of the study evaluated the feasibility of utilizing SimPPERT in nursing homes with actual CNAs performing PPE competency demonstrations during a clinical simulation scenario. For Phase II, the Texas Medical Foundation (TMF) collaborated with the study. The TMF is an independent review organization headquartered in Austin, Texas, and provided three RN staff located in Abilene, Dallas, and Austin to work with this study. The three TMF RN collaborators assisted with the study under the AHRQ grant because of their interest in the results of the study related to measurement of nursing home CNA PPE competency levels. The TMF routinely provides nursing home staff education and assesses the health outcomes of nursing home services. Therefore, the TMF was not only interested in the overall AHRQ study, but were particularly

interested in the SimPPERT portion of the study. The three TMF RNs also served on the TEP #1 in Phase I of the study.

In Phase II, the three TMF RNs conducted the clinical simulation scenarios and collected recorded videos of CNA PPE competency demonstrations. The TMF RNs were experienced in performing, teaching, and evaluating PPE skills in the nursing home, but had limited experience with clinical simulation scenarios or clinical simulation technology. As members of the TEP #1 in Phase I of the study, they had experience in utilization of the PPERT to rate PPE skills competency levels by observation of video performances. However, the researcher provided additional training on utilization of the PPERT, extensive training on implementing clinical simulation scenarios, and on utilization of the simulation technology. The TMF RNs conducted clinical simulation scenarios in nursing homes and video recorded 120 CNA demonstrations of PPE skills competency during a clinical simulation scenario.

The researcher designed a clinical simulation scenario and a script which detailed the CNA's role during the PPE competency demonstration. As in the clinical simulation scenario utilized in Phase I, the Phase II clinical simulation scenario required the CNA to provide personal care to a bed-bound nursing home resident on contact precautions for CDI. The scenario provided for the CNA to change the soiled briefs of the bed-bound nursing home resident (manikin). The TMF RNs briefed the CNAs on the clinical simulation scenario script prior to the start of each clinical simulation scenario. The script detailed that PPE be made available to the CNA outside the resident's room. The clinical simulation scenario starts with the CNA selecting and donning PPE, then

entering the room to provide personal care to the resident by changing the soiled briefs, and complete the scenario by doffing the PPE. The TMF RNs instructed the CNAs to verbalize rationales for all PPE selection, PPE donning, personal care to the resident, and PPE doffing during the clinical simulation scenario. The verbalized rationales assisted in evaluation of the PPE performance when RN raters viewed the video recordings. The clinical simulation scenario script also detailed the application of Glo Germ on strategic surfaces such as the bed rails, the manikin's perineal area, and the soiled briefs. Glo Germ is a lotion that contains a substance that emits an obvious glowing when viewed under ultra-violet light. Glo Germ is virtually invisible to the naked eye when applied to a surface and is frequently used for educational purposes to simulate the presence of microorganisms, such as C-diff. The TMF RNs conducted an ultraviolet light inspection of the CNA's clothing and exposed skin surfaces at the completion of the scenario to determine the presence or absence of Glo Germ. Presence of Glo Germ simulated contamination of the CNA with the infectious organism.

The researcher prepared a training curriculum to equip the TMF RNs to learn how to utilize the simulation technology to conduct the clinical simulation scenarios in nursing homes. The simulation technology equipment included manikins to serve as simulated nursing home residents, camcorders with accessories, and ultra-violet lights. Supplies included gloves, masks, gowns, red biohazard bags, hand sanitizer, briefs, and Glo Germ. Glo Germ is a substance used to simulate infectious organisms and is practically invisible to the naked eye when applied to surfaces such as skin or cloth. The application of ultra-violet light reveals the presence of Glo Germ on a surface as a

glowing substance. Hand sanitizer provided a distractor during the PPE doffing and an option for hand washing at the PPE donning station. Hand sanitizer will not kill *Clostridium difficile* organisms. Therefore, the CDC guidelines include mechanical removal of the organisms by hand washing with soap and water.

The three TMF RNs attended a one-day training session to familiarize them with the simulation technology utilized in the study and prepare them for conducting the clinical simulation scenarios. The TMF RNs received instruction on how to set up the clinical simulation scenario in the nursing home, how to operate the camcorders and related equipment, the implementation of the clinical simulation scenario script, and the break down and transportation of the clinical simulation equipment. Each of the TMF RNs signed for receipt of the clinical simulation equipment and supplies. The TMF RNs returned the clinical simulation equipment and unused supplies upon completion of the clinical simulation scenarios in the nursing homes.

The TMF RNs recorded portions of each clinical simulation scenario on two camcorders to ensure adequate viewing angles of all steps of the CNA PPE competency demonstrations. A hand held camcorder recorded the CNA performances outside the resident's room and a tripod-mounted camcorder along with the hand held camcorder provided two viewing angles of the performance inside the room. The use of two camcorders ensured adequate capture of the CNA PPE competency demonstration during the clinical simulation scenario.

2.3 Data Collection

Phase I addressed Research Question #1, is SimPPERT a reliable and valid method for the measurement of CNA PPE competency levels? Each member of both TEP #1 and TEP #2 worked alone and on their own time to view and rate the PPE performances in the eight videos. The following details the data collected during Phase I from the TEP #1 to address the question of the reliability of SimPPERT, and the TEP #2 to address the construct validity of the SimPPERT.

The TEP #1 members provided completed PPERT forms for each of the eight laboratory-produced and designed videos of a CNA actor performing various levels of PPE competency demonstrations. The TEP #1 provided a score on each of the six dimensions of the PPERT form for each video. The PPERT forms rating scores were transcribed into a spreadsheet, double-checked for accuracy in transcribing, and archived. The seven TEP #1 members provided 56 PPERT forms for a total of 336 observations, one observation for each of the six dimensions on each PPERT form. The TEP #1 members volunteered to participate without compensation.

The nine TEP #2 members provided completed face validity survey forms for each of the eight laboratory-produced and designed videos. The TEP #2 provided a Likert score between 1 and 5 (i.e., Very Bad to Very Good) on a Face validity survey form for each video. The face validity survey forms Likert scores were transcribed into a spreadsheet, double-checked for accuracy in transcribing, and archived. The nine TEP #2 members provided 72 face validity survey forms for a total of 72 observations, one

observation for each of the face validity survey forms. Each TEP #2 member was compensated \$20 for participation.

Phase II addressed Research Question #2, is SimPPERT a feasible method of measuring CNA PPE competency levels in nursing homes? Phase II was conducted in situ in eight nursing homes located in Abilene, Austin, and Dallas, Texas. The nursing homes participating in the study were for-profit, accepted both Medicare and Medicaid residents, and were approximately 100 to 200 beds in size. See Table 3 for the bed capacity of each nursing home. The nursing home sample was based on their homogenous characteristics to decrease the likelihood of structural differences biasing the results with influences other than PPE competency levels. Each nursing home representative signed the memorandum of understanding, that provided details of the study and other information required by the IRB approval. One hundred and twenty CNAs from the eight nursing homes participated in Phase II, 40 CNAs from each region.

Table 3: Nursing Home Bed Sizes

ID	Number of Beds
Abilene #1	123
Abilene #2	96
Abilene #3	217
Austin #1	118
Austin #2	110
Austin #3	120
Dallas #1	124
Dallas #2	120

The TMF RNs planned and implemented a training session on infection control procedures of PPE utilization for all CNAs within each nursing home participating in the study. The training session included information on utilization of PPE for residents on contact precautions and on the importance of utilizing PPE for residents diagnosed with CDI. The training sessions were incentives for the nursing homes to participate in the study and receive the benefit of required infection control training for their staff. Phase II did not include the training session on infection control procedures in the study, as the study focus was on the feasibility of implementing SimPPERT in nursing homes. The CNAs participating in the clinical simulation scenario portion of the study attended the infection control training session, provided informed consent signatures, and scheduled a time to conduct the clinical simulation scenarios. The CNAs received an incentive gift card of \$25 upon completion of their participation in the clinical simulation scenario portion of the study.

The TMF RNs recorded portions of each clinical simulation scenario on two camcorders to ensure adequate viewing angles of all steps of the CNA PPE skills competency demonstration. Each of the three TMF RNs provided the study with 80 video recordings, two video recordings from different viewing angles of 40 CNA performances, for 240 video recordings. The catalog of the videos included a video number, a nursing home code, and the TMF RN participating in each video. The TMF RNs provided the nursing home information and partial demographic information for each CNA, but the video catalog used only the nursing home code and CNA number to catalog the videos. If required, the study could use the video catalog to identify the

nursing home and CNA performing in each video by matching the video number to the nursing home information and CNA demographic information provided by the TMF RN researchers.

An independent contractor edited the two videos of each CNA's performance into a single video for viewing by the RN raters. The video editing did not delete any portion of the CNA performances relevant to PPE skills competency during the editing of the videos. The editing process resulted in 120 videos of 120 CNAs demonstrating PPE usage skills competency while providing personal care to a resident with CDI and on contact precautions during a clinical simulation scenario. A unique identification number from 001 to 120 identified the edited video in the catalog. The video legend and video identification number identifies the original, raw video recordings of the CNA performance, the RN researcher who recorded the video, and the nursing home in which the video was recorded. The researcher archived the raw and edited videos on an external hard drive with backup copies on a separate external hard drive.

The three TMF RNs participated in Phase I of the researcher and received training on utilization of the PPERT at that time. Phase II of the study included remediation training on how to utilize the PPERT form to address any knowledge decay, which may have occurred between Phases I and II of the study. The remediation training included viewing two of the laboratory videos during a one-hour telephone conference. After viewing each video performance, the RNs discussed each dimension of the PPERT and selected a rating score for that dimension. Then each participant provided their rationales for their selected rating score. The instructor provided feedback and correction

as necessary. This permitted each RN to compare other RNs' application of the PPERT to their own in an exercise designed to increase their competency in utilization of the PPERT. The remediation training also provided access to the original PPERT training webinar, copies of the CDC PPE guidelines and other training documentation from Phase I.

The three TMF RNs received copies of the videos in Windows Media Video format on digital video discs (DVD). Each RN viewed the 80 videos recorded by the other two RNs and provided a PPERT form with rating scores for each of the six PPERT dimensions of PPE utilization. DVD password protection and encryption safeguarded the integrity of the video contents and confidentiality of the CNAs in the study. The TMF RNs viewed and provided a rating on the PPERT form for each CNAs' PPE skills competency and returned the DVDs and the completed PPERT forms. This resulted in three sets of 80 PPERT forms (i.e., 240 total), two PPERT forms for each video. Each of the three RNs provided six dimension ratings on 80 PPERT forms totaling 1,440 observations. The researcher archived the DVDs in digital format and the TMF RN PPERT forms in digital and paper formats.

The Phase I reliability data and the Phase II nursing home data were analyzed with IBM SPSS version 23. The Phase I face validity data was analyzed using Stata version 11. The analysis included calculation of the Cronbach's alpha and ICC values. Cronbach's alpha provides an estimate of the internal consistency between the items being rated. The higher the Cronbach's alpha, the more internal consistency between the ratings, which indicates a higher reliability of the PPERT to measure the CNA PPE skills

level. Alpha values between .70 and .79 indicate fair internal consistency, values between .80 and .89 indicate good internal consistency, and values of .90 or above indicate excellent internal consistency (Cicchetti, 1994). In Cronbach's alpha formula shown below, N = number of items, c = average inter-item covariance among the items, and v = average variance.

$$\alpha = \frac{N \cdot c}{v + (N - 1) \cdot c}$$

ICC values provide information to estimate the proportion of variance in observations that is due to between-subject variability based on the true scores for the observation. The ICC values are high when there is a small amount of variation between the scores given to each item by the raters. A commonly cited classification of ICC values used in qualitative ratings of agreement is as follows: ICC values less than .40 are poor, values between .40 and .59 are fair, values between .60 and .74 are good, and values between .75 and 1.0 are excellent (Cicchetti, 1994). In the ICC formula shown below, K is the number of data values per group and \bar{x}_n is the sample mean of the n^{th} group.

$$r = \frac{K}{K - 1} \cdot \frac{N^{-1} \sum_{n=1}^N (\bar{x}_n - \bar{x})^2}{s^2} - \frac{1}{K - 1},$$

3. RESULTS

For Phase I, the evaluation of the SimPPERT methodology reliability and validity to measure CNA PPE skills levels, the study used a purposive sample of eight videos, nine TEP #1 members, and nine TEP #2 members. This would have provided 432 observations on PPERT forms by TEP #1 and 72 observations on the Face validity survey form by TEP #2 for analysis. Two of the TEP #1 members did not participate due to logistical reasons. This reduced the TEP #1 to seven members and 336 observations, which was sufficient for analysis.

The analysis of the TEP #1 data for reliability utilized both the intraclass correlation coefficient (ICC) to determine the proportion of interrater agreement between the TEP #1 raters and Cronbach's alpha (Cronbach, 1984) to determine the internal consistency between the TEP #1 ratings and TEP #2 ranking of the videos. Analysis of the TEP #2 data to determine the construct or face validity of the laboratory-produced videos to depict the designed level of PPE skills performances calculated the Cronbach's alpha to determine the internal consistency between the designed ranking and the TEP #2 ranking of the videos. The higher the Cronbach's alpha, the more internal consistency between the ratings, which indicates a higher reliability of the PPERT to measure the CNA PPE skills level. The Cronbach's alpha value for the laboratory video data was very high at .918 and indicates excellent internal consistency between the ratings of the eight laboratory-produced videos.

Phase I reliability analysis to measure the proportion of agreement between the raters utilized intraclass correlation coefficients (ICCs). The ICC was calculated for a sample of eight items (laboratory-produced videos) for the seven raters (TEP #1) using the two-way random effects model of ICC calculation (Landers, 2015). Landers (2015) explained that an ICC “Two-Way Random” assumes that the variance between raters is only adding noise, or error, to the estimate of what the data is rating. This noise, or error, should even out across many raters by using the means of their ratings. ICC two-way random is actually a way of controlling for rater effects when calculating an estimate of reliability. Average measure provides a better understanding of the reliability estimate, since it is controlling for the “noise” between the averages of the seven raters. The ICC for the proportion of agreement between the raters was equal to .918 with a 95% chance that the population reliability estimate falls between .786 and .981. There is evidence to support the reliability of this measurement between average ratings of the seven raters. See Table 5 for the ICC statistics when using the average measures.

For Phase II, the feasibility of implementing the SimPPERT methodology in nursing homes, a convenience sample of 120 CNAs participated in the study. The sample size of 120 CNAs was selected based on the available time for the TMF RNs to participate in the study as well as the funding and available time allotted for the AHRQ study. The 120 videos of CNAs performing PPE skills level demonstrations provided the data for two TMF RN raters to view each video and make 1440 observations on PPERT forms for analysis. Each TMF RN viewed the 80 videos recorded by the other two TMF

RNs and provided a PPERT form with rating scores for each of the six PPERT dimensions of PPE utilization.

3.1 Phase I Results

The Phase I reliability data consisted of 336 observations by seven TEP #1 raters recorded on the PPERT form by viewing the eight laboratory-produced videos. See Table 4 for the statistical summary of the Phase I reliability data. The PPERT form dimensions are labeled:

- Dimension 1 – Care and Risk Assessment
- Dimension 2 – PPE Handling
- Dimension 3 – Flow of Operation
- Dimension 4 – Self-Contamination
- Dimension 5 – Contamination of Environment
- Dimension 6 – Cross Contamination

Table 4: Summary Statistics of Phase I Reliability Data by Dimension

By Dimension				
	<i>n</i>	Mean	S.D.	Range Min - Max
Dimension 1	8	3.4	.91	1.7 – 4.4
Dimension 2	8	2.4	1.14	1 – 4.3
Dimension 3	8	3.0	.75	1.9 – 3.9
Dimension 4	8	2.0	1.02	1 – 3.9
Dimension 5	8	1.8	.30	1.4 – 2.3
Dimension 6	8	1.9	.65	1.1 – 2.9
Dimension values are average of 7 raters. n = sample size S.D. = Standard Deviation Possible dimension scores range from 0 – 5				

Table 5: Intraclass Correlation Coefficient for the Phase I Reliability Data

		95% Confidence Interval		F Test with True Value 0			
	ICC	Lower	Upper	Value	df1	df2	Sig.
Average Measures	.918	.786	.981	12.172	7	42	p<0.001
The ICC includes two-way random effects model where both rater effects and measure effects are random.							

A face validity study evaluated the construct validity of the laboratory-produced videos depictions of various PPE skills levels. The TEP #2 viewed the videos and provided assessments of the videos PPE skills level demonstration utilizing a Likert scale of 1 (Very Bad), 2 (Bad), 3 (Average), 4 (Good), and 5 (Very Good). The analysis

examined the TEP #2 Likert scale rankings for each video by ranking the average Likert scale score for each video. To compare the TEP #2 ranking of the videos to the designed ranking, the TEP #2 ranking of the videos was categorized into ‘Good’ (top two ranking videos), ‘Average’ (middle five ranking videos), and ‘Bad’ (lowest ranking video). See Table 6 for a comparison of the designed and TEP #2 video rankings.

Table 6: Designed and TEP #2 Video Ranking

Designed Quality	Designed Ranking	TEP #2 Ranking
Good	Video 1	Video 1
Good	Video 7	Video 7
Average	Video 3	Video 2
Average	Video 4	Video 3
Average	Video 5	Video 4
Average	Video 6	Video 6
Average	Video 8	Video 8
Bad	Video 2	Video 5

Analysis of the rankings assigned a value of 1 to the ‘Good’ videos, 2 to the ‘Average’ videos, and 3 to the ‘Bad’ videos and calculated Cronbach’s alpha value of internal consistency between the designed and the TEP #2 video rankings to be .7895, which is considered fair internal consistency. The obvious discrepancy between the designed and TEP #2 rankings was noted to be videos 2 and 5 where video 2 was ranked as ‘Bad’ by design, but as ‘Average’ by the TEP #2 and video 5 was ranked as ‘Average’ by design, but as ‘Bad’ by the TEP #2.

The results of the Phase I data analysis provide positive evidence to support Research Question #1 -- Is SimPPERT a reliable and valid method for the measurement of CNA PPE competency levels? The results provide evidence that the SimPPERT methodology and the PPERT measurement tool are reliable and valid when used to measure the PPE skills competency levels of a CNA actor viewed on video recordings demonstrating various levels of PPE skills. The reliability of the SimPPERT measurement tool was excellent with a Cronbach's alpha value of internal consistency between the ratings of .918 and the ICC value of the proportion of agreement between the raters of .918.

The face validity portion of Phase I assessed the construct validity of the videos to depict the designed levels of PPE skills. The analysis compared the designed video ranking with the TEP #2 ranking to assess the fidelity of the designed video ranking. The Cronbach's alpha of internal consistency between the designed video ranking and the TEP #2 video ranking shows a value of .7895, which is a fair level of internal consistency.

The face validity assessment shows the video rankings of TEP #2 to be similar to the designed video ranking. The exception noted was related to video 2 and video 5. The researcher could identify no rationale for why the TEP #2 ranking perceived video 2, the video designed to be extremely 'Bad', as an 'Average' video, while video 5, a video designed to be 'Average', was perceived to be 'Bad'.

The results of the Phase I data analysis provide evidence that the SimPPERT methodology and the PPERT measurement tool are capable of providing a reliable and

valid quantitative measurement of CNA PPE competency levels in the laboratory setting. This study adds to the current knowledge regarding the reliability and validity of the PPERT measurement tool beyond the study conducted by Williams and Carnahan (2013). Williams and Carnahan (2013) did not examine the PPERT measurement tool's reliability and validity in providing a quantitative measurement of the PPE skills level in health professionals using laboratory designed and produced videos.

3.2 Phase II Results

Phase II assessed the feasibility of implementing the SimPPERT methodology in nursing homes with CNAs performing PPE skills demonstrations and RNs rating the performances by viewing a video of the PPE skill performance. As such, no statistical correlations were made on the Phase II data collected during the feasibility portion of the study to assist in determining the feasibility of implementing the SimPPERT methodology in nursing homes. However, analysis of the Phase II data provides a demonstration of the potential usefulness the data to ascertain the PPE skills competency levels of nursing home CNAs.

Table 7 shows summary statistics for the Phase II data by PPERT form dimensions. Table 8 shows summary statistics for the Phase II data by total video score, a sum of all six dimensions in each video. Table 9 shows the summary statistics for the Phase II data by total video score and by nursing home. The data shown and analyzed in

Table 7, Table 8, and Table 9 is the average score of the two raters for each dimension and total video score of the 120 videos in the sample.

Table 7: Summary Statistics of Phase II Data by Dimension

By Dimension				
	<i>n</i>	Mean	S.D.	Range Min - Max
Dimension 1	120	3.9	.45	2 – 5
Dimension 2	120	2.6	1.19	1 – 5
Dimension 3	120	3.7	.77	1.5 – 5
Dimension 4	120	2.5	1.27	1 – 5
Dimension 5	120	3.0	1.28	1 – 5
Dimension 6	120	3.1	1.31	1 – 5
Dimension scores are average of 2 raters. <i>n</i> = sample size S.D. = Standard Deviation Possible dimension scores range from 0 – 5				

Table 8: Summary Statistics of Phase II Data by Video

By Video			
<i>n</i>	Mean	S.D.	Range Min - Max
120	18.9	4.73	9 – 28.5
Video scores are average of 2 raters for all dimensions summed per video. <i>n</i> = sample size S.D. = Standard Deviation Possible video scores range from 0 – 30			

Table 9: Summary Statistics of Phase II Data by Video and by Nursing Home

By Video By Nursing Home				
	<i>n</i>	Mean	S.D.	Range Min – Max
Nursing Home A	20	19.5	3.59	12 – 27
Nursing Home B	11	19.8	4.84	14.5 – 28
Nursing Home C	9	19.2	5.27	11 – 26.5
Nursing Home D	20	19.8	5.88	10 – 28.5
Nursing Home E	20	18.9	4.59	11 – 26
Nursing Home F	13	16.2	2.58	11.5 – 19.5
Nursing Home G	16	16.4	4.12	9 – 21.5
Nursing Home H	11	20.7	5.53	11.5 – 28.5
Video scores are average of 2 raters for all dimension scores per video <i>n</i> = sample size S.D. = Standard Deviation Possible video scores ranged from 0 – 30				

For the Phase II nursing home data, the Cronbach's alpha value between the two raters viewing and rating the videos was .603. This is below the .70 level considered a fair internal consistency and indicates insufficient internal consistency between the ratings. The poor Cronbach's alpha level of .603 may be the result of having only two raters.

The ICC was calculated for the sample with two raters using the two-way random effects model. ICC two-way random effects model is a way of controlling for rater effects when calculating an estimate of reliability by using the average measure of the raters. The average measure provides a better understanding of the reliability, since it is controlling for the "noise" between the two raters. The average measures ICC was equal to .603 with a 95% chance that the population reliability estimate falls between

.488 and .692. The ICC value of .603 is considered a good proportion of agreement between the raters (Cicchetti, 1994). See Table 10 for the ICC statistics.

Table 10: Intraclass Correlation Coefficient for the Phase II Data

		95% Confidence Interval		F Test with True Value 0			
	ICC	Lower	Upper	Value	df1	df2	Sig.
Average Measures	.603	.488	.692	12.172	239	239	p<0.001
The ICC includes two-way random effects model where both rater effects and measures effects are random.							

Phase II of the study evaluated the feasibility of implementing the SimPPERT methodology in the nursing home setting, not the internal consistency between the ratings or the proportion of agreement between the raters of the PPERT data. The study did successfully demonstrate that implementation of the SimPPERT methodology is feasible in the nursing home setting by collecting video data of 120 CNA PPE competency level performances.

The Phase II results provide positive evidence to support Research Question #2 -- Is SimPPERT a feasible method of measuring CNA PPE competency levels in nursing homes? The data analysis results provide evidence that the SimPPERT methodology is feasible to implement in the nursing home setting by recording videos of actual CNAs providing a demonstration of their PPE skills competency levels during a clinical simulation scenario. The discussion section provides a functional example of the type of

data SimPPERT is capable of capturing when implemented in the nursing home setting with CNAs and how that data can provide useful information on CNA PPE skills level. The fact that both the less than satisfactory internal consistency value (Cronbach's $\alpha = .603$) and the good proportion of agreement value ($ICC = .603$) were much lower than in Phase II than in Phase I may be related to having only two raters in Phase II and seven raters in Phase I. More raters for the Phase II data may have improved the internal consistency between the ratings and the proportion of agreement between the raters.

4. CONCLUSION

Cardo et al. (2010) purported that the effort to eliminate HAIs would require reliance on the following three criteria: implementation of evidence based practices, the closing of knowledge gaps, and development of novel prevention tools. This study has added to the literature to help close the knowledge gap related to measurement of CNA PPE competency levels. It also demonstrated the SimPPERT methodology is a novel, reliable, and valid measurement tool capable of implementation in nursing homes to ensure CNA PPE competency levels are meeting evidence based practice standards. The SimPPERT methodology successfully meets the criteria established by Cardo et al. (2010) to be identified as a novel prevention tool to combat transmission-based HAIs in nursing homes.

The data produced by the SimPPERT methodology in Phase II of this study provide a potential for analyses at several levels (e.g., individuals and groups) and in several forms (i.e., individual and combinations of dimensions; individual and combinations of PPERT total scores; nursing home groups). The following discussion of the Phase II nursing home data offers examples of the robust data provided by the SimPPERT methodology.

In the Phase II nursing home data, the SimPPERT methodology includes data at the individual CNA level and at the nursing home level. The SimPPERT methodology provides a score for the individual CNA PPE competency level by six dimensions permitting the targeting of various deficiency areas (i.e., knowledge of PPE, proficiency

in donning and doffing, avoidance of contamination of the environment, self, and the patient) for future education and training to improve individual PPE competencies. Targeting individual CNA PPE competency levels is a method of addressing the process portion of the patient safety and outcome issues.

The SimPPERT methodology also provides a score at the nursing home level by summing each of the six PPERT dimension scores by CNA for a total PPE competency score, then averaging the sum of those CNA total PPE competency scores by nursing home to calculate a nursing home PPE score. This aggregation of the PPERT scores permits evaluation of the structural and process portions of the patient safety and outcome issues for any nursing home. In these manners, the SimPPERT methodology can provide valuable data for assessing the PPE competency levels of CNAs by dimensions at the individual and the nursing home levels.

The data analysis of the PPERT total CNA PPE competency scores by nursing home reveals information on the PPE competency levels of the eight nursing homes in the study. The total PPE competency score on the PPERT for each CNA PPE performance could range from 0 to 30 points (0 to 5 points for each of six dimensions). While no studies have set a benchmark as an acceptable PPERT rating score for CNA PPE competency, the researcher established a PPERT score of 22.5 as the benchmark of an acceptable score for individual CNA and nursing home PPE competency levels for purposes of demonstrating the utility of the SimPPERT methodology in assessing individual CNA and nursing home PPE competency levels. The 22.5 PPERT score is the equivalent to 75% of the possible PPERT points. Using a PPERT score of 22.5 as the

benchmark to demonstrate how the SimPPERT methodology can provide a quantitative measurement for CNA PPE competency levels, the data shows that all eight nursing homes failed to meet the minimal standard of CNA PPE competency level when assessed by the average PPERT scores for all CNAs by nursing home. The average PPERT scores by nursing home ranged from 16.19 to 20.73. This suggests a need by all nursing homes in this study to improve the PPE skills portion of their infection control programs. The total PPERT scores by each individual CNA ranged from 9 to 28.5. The data show that while some CNAs were capable of performing PPE competency at a high level, many were incapable of doing so. This individual inability to demonstrate competent PPE skills negatively affects the PPE competency level of the nursing home as a whole, threatens patient safety and health outcomes, and suggests a need for improving the PPE competency levels of the CNAs in this study.

The individual CNA PPERT scores for each dimension could range from 0 – 5. While no studies have identified an acceptable PPERT score for each dimension, the researcher set a PPERT score of 4 as the lower benchmark for an acceptable individual dimension score. A PPERT score of 4 is equivalent to 80% of the possible 5 points on the PPERT for each dimension and is used for the purpose of demonstrating the utility of the SimPPERT methodology in assessing CNA PPE competency levels. The nursing home data show that approximately 25% of individual CNAs scored below the minimal PPERT score of 4 as an average score for the knowledge dimensions; the dimensions that evaluate selection of appropriate PPE, donning and doffing, and flow of procedure. Approximately 50% of individual CNAs scored below the minimal PPERT score of 4 as

an average score for the performance dimensions; the dimensions that evaluate contamination of the environment, self, and the patient. It may be more practical to apply separate benchmarks to the individual PPERT dimensions as each dimension has the potential to pose a greater or lesser threat of harm to the patient. A higher benchmark for the three performance dimensions (contamination of environment, self, or patient) compared to the three knowledge dimensions (selection, donning and doffing, and flow of procedure) may be warranted due to the performance dimensions posing a larger threat to patient safety and outcomes than some aspects of the knowledge dimensions. For example, a CNA may score low on the 'Care and Risk Assessment' dimension by choosing incorrect PPE. This incorrect selection choice could represent a higher level of protection than the CDC guidelines specify for a patient on contact precautions. This may represent an undesirable outcome for the nursing home as a form of waste, but poses no additional safety and health outcome risks for the patient. Therefore, future studies may determine it is prudent to set the minimal score for PPERT knowledge dimensions lower than for performance dimensions.

The SimPPERT methodology shows promise as a tool for predicting the likelihood of improper PPE utilization of a particular CNA, or by a particular nursing home, being culpable in the spread of transmission-based HAI. The ability to assess the competency level of the nursing home CNA staff by averaging the total PPERT scores for all CNAs by nursing home could provide more information on how well the nursing home is performing infection control training and implementation on a macro scale. The ability to assess the competency level of the nursing home CNA staff by averaging the

PPERT dimension scores for all CNAs by dimension could provide more information on how well the nursing home is performing infection control training and implementation on a micro scale. The micro type information would permit targeting of identified areas of deficiencies (e.g., knowledge of PPE, proficiency in donning and doffing, avoidance of contamination of the environment, self, and the patient) in the nursing home infection control program for future education and training opportunities. Repeated evaluations of the nursing home CNA staff by the SimPPERT methodology could be useful in evaluating the effectiveness of the enhanced infection control program education and training. This study identified no threshold for the level of CNA PPERT scores that would indicate a need for infection control improvement. However, the CNA PPERT scores in this study appear to suggest that most, if not all, of the nursing homes in this study need improvements to PPE infection control training.

Looking at the data from the nursing home level provides a good view of the ranking of the nursing homes based on their CNAs' performance of PPE skills competency. It is possible that increasing the number of nursing homes in the study and comparing the PPERT score ratings with future incidence rates for transmission-based HAIs would assist in identifying nursing homes at higher risk for transmission-based HAIs. Targeting these nursing homes with programs designed to improve their infection control training sessions may have an impact on lowering the transmission-based HAI incidence rates. The same logic suggests that a program utilizing the SimPPERT methodology would provide a method of monitoring nursing home dedication to improving infection control training for CNAs.

4.1 Future Studies

This study's successful demonstration of the feasibility of implementing SimPPERT in nursing home facilities to measure CNA PPE competency levels suggests the potential for employing the SimPPERT methodology as a PPE competency level measurement tool for all nursing home staff. The researcher is optimistic that future studies will be able to build on the findings of this study to demonstrate that the PPERT is also a reliable and valid instrument for measuring the PPE competency levels of all types of health care personnel in many other health care settings. Many of the following suggestions and recommendations for future studies are adaptable to all types of health care personnel in many types of health care settings.

Future studies should investigate using the SimPPERT methodology to assess the PPE skills competency of nursing home staff such as environmental services, orderlies, dietitians, social workers, medication aides, certified nursing assistants, licensed vocational nurses, registered nurses, nurse practitioners, physicians, and administrative personnel, guests, volunteers, and family members as appropriate. The data collected through implementation of the SimPPERT methodology to assess all nursing home staff may identify deficiencies in the facility's PPE protocol implementation and assist with guiding the facility toward appropriate interventions to address those deficiencies.

The SimPPERT methodology is adaptable to all levels of PPE transmission-based protocols including contact precautions, droplet precautions, and airborne precautions. Looking at the SimPPERT data from the nursing home level provides a

good view of the ranking of the nursing homes based on their staff performance of PPE skills competency. Future studies should evaluate the SimPPERT methodology as a predictive tool in detecting the likelihood of a facility contributing to the spread of transmission-based HAIs by the improper utilization of PPE when the facility is providing care for residents or patients with transmission-based infectious diseases. A longitudinal study comparing the SimPPERT PPE competency scores of facility staff with facility incident rates of transmission-based HAIs may reveal a correlation. For instance, the conceptual relationship between HAI risk and PPE skill levels in this study surmised high SimPPERT scores should indicate low incidence rates, and vice-versa. If studies find a correlation between SimPPERT scores and transmission-based HAIs, repeated evaluations of facilities should permit researchers to determine an acceptable threshold for SimPPERT scores. The investigators could compare the facility SimPPERT score to the threshold score to determine if the facility staff's PPE usage is increasing the risk of HAI. The investigators may consider a facility demonstrating less than the acceptable SimPPERT score to be at risk of spreading transmission-based HAIs to residents or patients through incompetent utilization of PPE and inform the facility of the need for increased or improved infection control training. The facility could repeat SimPPERT evaluations until the facility staff obtain an acceptable SimPPERT score. Targeting these nursing homes with programs designed to improve their infection control training sessions may have an impact on lowering the transmission-based HAI incidence rates. The same logic suggests that a program utilizing the SimPPERT

methodology would provide a method of monitoring nursing home dedication to improving infection control training sessions for CNAs.

Future studies may find the SimPPERT methodology to be helpful in identifying nursing home staff non-compliance with infection control practices. If the SimPPERT scores are acceptable and incidence rates are higher than acceptable, it may be an indicator that facility staff are not complying with infection control practices in spite of the demonstrated high levels of PPE competency. A recent study on healthcare workers' non-compliance with infection prevention and control practices found rationales for health care workers non-compliance to have three main themes including hierarchy of influence, prioritization and risk assessment, and attribution of responsibility (Shah, Castro-Sánchez, Charani, Drumright, & Holmes, 2015). In relation to the prioritization and risk assessment theme of non-compliance with institutional policies on infection control practices, Shah et al, (2015) reports that one senior nurse interviewee in the study said,

“Nurses know what they’re supposed to be doing, and when they don’t do it, it’s because we’re too busy, short staffed, too stretched, they’re cutting that corner when they feel under pressure to prioritize other things.” (p. 7)

While other factors may also contribute to non-compliance with infection control practices by health care workers, prioritization and risk assessment rationales for non-compliance with infection control practices appears amenable to identification by implementation of the SimPPERT methodology. This information may lead to

implementation of behavior modification practices designed to address identified rationales for non-compliance with institutional policies on infection control practices.

The results of this study may inspire future studies to employ novel interventions from portions of the SimPPERT methodology to address issues such as non-compliance with infection control practices. These novel interventions may assist in reducing the incidence of transmission-based HAIs in nursing homes and other facilities. For instance, installation of video cameras at the entrances to all rooms of residents or patients on transmission-based precautions would permit visualization of the PPE compliance level of all personnel entering the room. This intervention may encourage and improve personnel compliance with infection control practices for transmission-based precautions, e.g. contact, droplet, and airborne precautions. The researcher feels it is realistic to expect those effective novel interventions to be adapted in other health care settings and with other health care professionals as well.

4.2 Limitations

The PPERT instrument utilized in the SimPPERT methodology does demonstrate strong potential for being a reliable and valid tool for assessing and measuring the PPE skills competency of CNAs in the nursing home setting. However, the researcher feels the difference in the number of raters for Phase I and Phase II of the study was a limitation to obtaining similar internal consistency values and proportion of agreement values in each Phase. The study utilized seven raters in Phase I, and two raters in Phase

II of the study. The study found the Phase I internal consistency values between the ratings and proportion of agreement values between the seven raters was very high (Cronbach's $\alpha = .918$; ICC = .918). But in Phase II they were much less than those in Phase I (Cronbach's $\alpha = .603$; ICC = .603). The study feels the internal consistency and proportion of agreement for Phase II may have been comparable to Phase I, if Phase II had provided the same number of raters.

The researcher recognizes the limitations of the face validity study performed in Phase I of this study as being insufficient to provide more than the opinion of a small group of health care professionals, not from a panel of subject matter experts (SME). A panel of SMEs would have been more appropriate for conducting a robust face validity study through approaches such as independently reviewing and rating the video PPE performances and voting on a consensus of the video rankings as good, average, or bad. This studies time constraints and limited resources for the face validity portion of the study, which was not funded by the AHRQ, seriously limits the results of the face validity to providing any more than TEP #2's individual opinions of videos ability to provide realistic portrayals of PPE skills demonstrations as good, average, or bad.

The study sample for Phase II was fairly homogenous in characteristics and from only three different regions of Texas. The eight nursing homes participating in the study were for-profit, accepted both Medicare and Medicaid residents, and were approximately 100 to 200 beds in size, and from three regions of Texas: Abilene, Austin, and Dallas. The study did not have the resources to increase the sample size by collecting data from more nursing homes in other regions of Texas, or other areas of the country. This

represents a limitation of the study results generalizability to nursing homes in other regions with different characteristics.

Another limitation to this study was the lack of CNA demographic information, which could have analysis of response data. Analysis of CNA PPE skills competency and CNA demographic characteristics such as age, gender, years of experience, and educational level may have produced interesting results related to PPE skills competency.

Another limitation to this study is the SimPPERT methodology measurement of CNA PPE skills competency levels. The measurement of PPE skills competency during a clinical simulation scenario provides only an estimate of the actual PPE skills competency during provision of patient care. Clinical simulation scenarios are purposely designed to meet specific objectives and only mimic real clinical situations (Waxman, 2010). The constraints of the clinical simulation scenario remove many of the naturally occurring variations in the process of performing PPE skills. For example, the nursing home resident in this study's clinical simulation scenario was a manikin, which did not offer any resistance to the procedure, ask distracting questions, or otherwise interfere with the procedure during the PPE skills demonstration as might happen in a real-life situation. It is possible that a CNA performing PPE skills satisfactorily during a clinical simulation scenario will perform unsatisfactorily in a real-life situation. However, this study focused on PPE competency and not PPE compliance. In other words, this study looked at determining if the CNA had the skills to properly utilize PPE and not at whether the CNA actually performs proper PPE utilization with nursing home residents.

It is possible that a CNA could demonstrate very proficient PPE skills competency in a clinical simulation scenario, but fail or neglect to perform PPE skills at that same competency level when caring for actual patients. This may be a result of the participant knowing they are being observed and performing differently for the observer than the participant performs in reality, sometimes referred to as the Hawthorn effect (Wickström & Bendix, 2000).

Since it is unrealistic to expect a precise measurement of the PPE skills competency level of a health professional while performing in a clinical simulation scenario, the SimPPERT methodology provides only an estimate of the PPE skills competency level. However, one quality of clinical simulation scenarios is their ability to be reproduced and repeated as often as needed (Jeffries, 2005). This study may have been improved by utilizing repeated measurements of CNA PPE skills competency.. Repeated measurements of PPE skills competency utilizing the SimPPERT methodology should enhance the CNA's suspension of disbelief enabling them to perform as if in a real-life situation and should produce an improved measurement of PPE skills competency levels. The repetition of the competent PPE demonstrations may serve as a self-instruction and reinforcement of the task in the health professional's mind, thereby enhancing their actual PPE competency level in real life situations (Ford, Quiñones, Sego, & Sorra, 1992; Gist, Bavetta, & Stevens, 1990).

4.3 Closing

This study discussed the impact of transmission-based HAIs on nursing home residents and identified CNA PPE competency as a contributing factor to nursing home resident safety and health outcomes associated with transmission-based HAIs. The study addressed the lack of an effective method to measure CNA PPE competency levels in the nursing home by utilizing simulation technology combined with a PPE Rating Tool (SimPPERT) to measure CNA PPE competency levels by observing a demonstration of PPE skills during a clinical simulation scenario. The study results provide evidence that SimPPERT is a valid and reliable method of measuring CNA PPE competency levels as well as evidence of the feasibility of implementing the SimPPERT methodology in nursing homes.

The study contributes to the literature by providing valuable insight to effective methods of measuring PPE competency levels. The study found SimPPERT to be a reliable and valid methodology for measuring the PPE competency levels of nursing home CNAs. And the study demonstrated the feasibility of implementing the SimPPERT methodology in nursing homes. These findings may be useful to future studies in development of novel interventions, which may reduce the incidence of transmission-based HAIs in nursing homes and other health care settings.

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